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Photonic Processing at NASA Ames Research Center

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The Photonic Processing group is engaged in applied research on optical processors in support of the Ames vision to lead the development of autonomous intelligent systems. Optical processors, in conjunction with numeric and symbolic processors, are needed to provide the powerful processing capability that is required for many future agency missions. The research program emphasizes application of analog optical processing, where free-space propagation between components allows natural implementations of algorithms requiring a large degree of parallel computation. Special consideration is given in the Ames program to the integration of optical processors into larger, heterogeneous computational systems. Demonstration of the effective integration of optical processors within a broader knowledge-based system is essential to evaluate their potential for dependable operation in an autonomous environment such as space.

The Ames Photonics program is currently addressing several areas of interest. One of the efforts is to develop an optical correlator system with two programmable spatial light modulators (SLMs) to perform distortion invariant pattern recognition. Part of this work has been to develop a new type of filter to be placed in the spectral plane that uses information in the design procedure about the particular SLM on which it will be implemented. Laboratory work is aimed at the verification of this filter's performance. The SLM device used in our laboratory is an electronically-addressable magneto-optic array known as a SIGHT-MOD. An electronic controller for the SIGHT-MOD has been designed, built, and is currently being tested; the controller will be able to store 100 filters used for object recognition and rapidly address the device with a desired sequence of filters. This high-speed I/O capability is a key step in plans to integrate the optical processor with a knowledge-based system for image recognition and classification.

Another area of research is optical neural networks, also for use in distortion-invariant pattern recognition. Most promising of the models investigated are higher-order neural networks; to date, a small third-order net which distinguishes two objects regardless of size, position, or rotation has been demonstrated in software. The large number of interconnections needed in these architectures leads to consideration of optical implementations. Experimental work on developing an optical neural network will involve evaluating holographic implementations of weighted network connections, as well as testing optical or hybrid optical/electronic implementations of thresholding units to realize neuronic elements.

Optical matrix processors are being investigated for implementing neural net techniques to perform multispectral data analysis. The problem is to sort out three-dimensional (x,y,lambda) data and determine for every pixel in a scene all minerals present, amount of each, and estimate spectrum of unknown elements. This type of analysis is needed for site selection and sample analysis on planetary explorations as well as many types of astronomical and earth sensing data.